



# Cape Cod Bridges Program

## Bourne, Massachusetts

### Appendix 3.1 Alternatives Assessments Technical Report

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## Acronyms and Abbreviations

| Acronym/Abbreviation | Definition                                                      |
|----------------------|-----------------------------------------------------------------|
| FHWA                 | Federal Highway Administration                                  |
| MassDOT              | Massachusetts Department of Transportation                      |
| MRER/EA              | Major Rehabilitation Evaluation Report/Environmental Assessment |
| NEPA                 | National Environmental Policy Act                               |
| USACE                | U.S. Army Corps of Engineers                                    |
| USC                  | United States Code                                              |

# 1 Introduction

Documentation of the Massachusetts Department of Transportation's (MassDOT)s extensive alternatives assessment process is provided in support of the Draft Environmental Impact Statement for the Cape Cod Bridges Program (Program), in accordance with the following federal and state statutes, regulations, and guidance:

- National Environmental Policy Act (NEPA) of 1969, as amended, 42 United States Code (USC) 4321 et seq.
- *Efficient Environmental Reviews for Project Decisionmaking and One Federal Decision*, 23 USC 139.
- Federal Highway Administration's (FHWA) regulations implementing NEPA, *Environmental Impact and Related Procedures* (23 Code of Federal Regulations [CFR 771]), and corresponding guidance, Technical Advisory (T 6640.8A): *Guidance for Preparing and Processing Environmental and Section 4(f) Documents* (October 30, 1987).

## 2 Summary of Program's Alternatives Analysis Process

In coordination with the U.S. Army Corps of Engineers (USACE) and the FHWA, and incorporating input from stakeholders and the public, MassDOT developed a multi-step filtering process for identifying and evaluating alternatives for the Program. MassDOT documented its alternatives assessment process in the following reports:

- **Attachment 1, Cape Cod Bridges Program Alternatives Analysis Report** (May 2025), which provides the following analyses:
  - Details of the screening of the USACE's Major Rehabilitation Evaluation Report/Environmental Assessment (MRER/EA) alternatives and recommendation for in-kind bridge replacement
  - Assessments and identification of the recommended bridge highway cross-section and shared-use path, bridge vertical and horizontal clearance, main span length and bridge pier location, bridge deck configuration, mainline alignment location, and bridge type
  - Initial assessment of highway interchange approach options resulting in advancement of ten options for a detailed evaluation
- **Attachment 2, Cape Cod Bridges Program Highway Interchange Approaches Detailed Assessment Report** (May 2025), which provides details of the secondary evaluation of ten interchange approach options that passed the initial assessment and resulted in a single pairing of options for each replacement bridge crossing.

## 3 Summary of Alternatives Analysis Report

This section summarizes the eight engineering assessments that comprise **Attachment 1**. For some Program design parameters, MassDOT's analyses consisted of a single evaluation; for other parameters, an initial assessment followed by a detailed evaluation was required to arrive at the final recommendation.

### 3.1 Screening of Alternatives Considered in USACE's Major Rehabilitation Evaluation Report/Environmental Assessment

Pursuant to 23 USC 139(f)(4)(E)(ii), the Program builds upon and references prior, multi-year foundational studies, including the USACE's MRER/EA of the Cape Cod Canal highway bridges.

In coordination with FHWA, MassDOT conducted an independent conceptual screening of 12 alternatives presented by the USACE in the MRER/EA. The twelve alternatives comprised the "Universe of Alternatives" for addressing the deteriorating Sagamore and Bourne Highway Bridges.

MassDOT evaluated the alternatives in accordance with FHWA's regulations NEPA implementing regulations, 23 CFR 771, and its Technical Advisory (T 6640.8A): Guidance for Preparing and Processing Environmental and Section 4(f) Documents. MassDOT reviewed the USACE MRER/EA alternatives relative to the Program's Purpose and Need Statement and NEPA guidance for evaluating alternatives for reasonableness.

MassDOT determined that replacing both bridges with two new adjacent bridges at each crossing location, each providing two through-traffic lanes and an auxiliary lane in each direction and built to current design standards, would meet the identified Program needs to address the escalating bridge maintenance demands and improve traffic operations and accommodations for pedestrians and bicyclists. Based on its ability to fully meet the Program needs, while minimizing the approach road modifications necessary to connect the replacement bridges to the regional and local transportation system, MassDOT recommended advancing the Four Travel Lanes and Two Auxiliary Lanes Replacement Alternative (Replacement Highway Bridges Built to Modern Design Standards) as presented in the MRER/EA for further consideration. MassDOT's recommendation for Replacement Highway Bridges Built to Modern Design Standards, which concurs with the USACE's Preferred Alternative, was the basis for assessing the Program design parameters.

MassDOT determined that the 11 remaining alternatives from the MRER/EA's Universe of Alternatives were not reasonable alternatives. However, per NEPA, the No Build Alternative is retained in the Environmental Impact Statement as the base condition against which all other alternatives are compared and evaluated.

### **3.2 Assessment of Bridge Highway Cross-Section and Shared-Use Path**

In accordance with MassDOT and FHWA design criteria, as well as American Association of State Highway and Transportation Officials (AASHTO) guidelines, MassDOT evaluated proposed bridge highway cross-section and the maximum profile grades relative to the MRER/EA's recommendations that each new bridge would include four 12-foot-wide through travel lanes, two in each direction; two 12-foot-wide auxiliary lanes, one in each direction; a shoulder; a separation median; and approach grades. MassDOT determined that the proposed shared-use path at each canal crossing would be designed in accordance with MassDOT, AASHTO, and FHWA design criteria, as well as the guidance of the Americans with Disabilities Act and the Architectural Access Board.

### **3.3 Assessment of Bridge Vertical and Horizontal Clearances**

MassDOT evaluated the vertical and horizontal clearances for the replacement bridges relative to the recommendations presented in the USACE's MRER/EA. The MRER/EA indicated that to maintain the existing vertical clearance of 135 feet above mean high water, the height of the new bridges should be increased to accommodate fluctuations in relative sea level. Additionally, the USACE indicated that horizontal clearance for navigation must be considered with the replacement bridge design.

MassDOT recommended an increase in bridge height by three feet, which would maintain the existing vertical clearance at 135 feet above mean high water and would accommodate fluctuations in relative sea level. Incorporating the USACE's recommendation regarding navigation, MassDOT recommended that the replacement bridge structures provide a minimum of 500 feet of horizontal navigational width, to be consistent with existing conditions.

### **3.4 Assessment of Main Span Length and Bridge Pier Location**

The bridge piers for the existing Sagamore and Bourne Bridges are within Cape Cod Canal and outside the navigation channel and support a mainline center span length of 616 feet. MassDOT evaluated the USACE's preference for locating the proposed bridge piers outside of the canal cut to improve navigation, operations, and maintenance, as indicated in the MRER/EA.

MassDOT conducted an initial assessment of the main span length and bridge pier location against the applicable bridge design evaluation criteria of costs, main span footings and construction. This initial assessment resulted in a recommendation for an out-of-water pier location with two potential main span lengths of approximately 700 feet and 820 feet. MassDOT further evaluated the two main span lengths as part of a detailed bridge fabrication and erection methodology analysis for the bridge type. This second assessment contributed to a final recommendation for an approximate 700-foot main span with the bridge piers located within the rip-rap slope and above the low tide line.

### 3.5 Assessment of Bridge Deck Configuration

As a variation of the single bridge deck configuration presented in the MRER/EA, MassDOT investigated constructing two separate deck structures for each replacement highway bridge, consisting of two parallel separate northbound and southbound decks (barrels). MassDOT's qualitative assessment focused on the constructability aspects of the bridge deck configuration, including duration of construction, construction complexity, and potential for construction phasing. MassDOT also evaluated the durability and structural redundancy aspects of the bridge deck configurations.

Based on its initial assessment, MassDOT determined that both bridge deck configurations would be feasible depending on the bridge type and advanced the single deck and two separate deck options for further evaluation. After a secondary evaluation that assessed the bridge deck configuration relative to a short list of bridge types, MassDOT recommended advancing the two separate deck configurations as part of the final bridge type recommendation.

### 3.6 Assessment of Mainline Alignment Location

MassDOT assessed the MRER/EA's recommendation that the two new highway bridges be constructed parallel to and immediately in-shore of the existing Sagamore and Bourne Bridges (offline and inboard). MassDOT identified five optional locations for each highway bridge mainline alignment over Cape Cod Canal and evaluated the locations based on their performance in meeting the Program needs to address the substandard design elements of the bridges relative to the mainline approaches and their adjacent interchanges and intersections, improve vehicular traffic operations, and improve accommodations for pedestrians and bicyclists. Additional objectives included minimizing temporary and permanent environmental effects, including right-of-way effects and effects to the traveling public.

Based on the results of its performance relative to meeting the Program's highway design evaluation criteria, the Fully Offline Inboard Option for both the Sagamore Bridge and Bourne Bridge locations had an overall higher rating than the other mainline alignment location options. As a result, MassDOT recommended advancing the Fully Offline Inboard Option for both canal crossings as the mainline alignment location retained for detailed study.

### 3.7 Assessment of Bridge Types

MassDOT's assessments of bridge types for the replacement highway bridges consisted of a conceptual screening of a Universe of Concepts, followed by initial and detailed evaluations.

Incorporating the USACE's Preferred Alternative for In-Kind Bridge Replacements, and in collaboration with FHWA and USACE, MassDOT conceptually screened a wide range of bridge types and design parameters to identify feasible bridge types and configurations for further analysis. In this conceptual screening, MassDOT identified the decision drivers for bridge type selection, advanced favorable design features, and eliminated unfavorable bridge types.

MassDOT then conducted an initial assessment of a short list of bridge types relative to the Program's bridge design evaluation criteria. MassDOT placed highest priority on bridge types that would be practical and feasible to construct and maintain; bridge types that would not be practical and feasible

were not advanced for further evaluation. Additionally, MassDOT placed high priority on a bridge construction method that would minimize Cape Cod Canal navigation effects. As a result of this initial assessment, MassDOT recommended the advancement of three bridge types with various configurations for a secondary evaluation.

MassDOT's detailed analysis incorporated MassDOT's highway geometric assessments, additional constructability assessments of the feasible bridge types (including a detailed bridge deck configuration assessment), and the public's review of the feasible bridge types relative to community considerations and bridge aesthetics. As a result of the detailed bridge type assessment, including public input, MassDOT recommended the following bridge type to be retained for detailed study: parallel, twin tied-arch bridge structures supported on Delta frames with an approximate 700-foot main span length. As design advances, MassDOT will determine exact span length, arch rib configuration, tie-in with approach ramps, and other parameters for the Tied-Arch Bridge with Delta Frame, which will be included in the Program Bridge Type Study.

### 3.8 Assessment of Highway Interchange Approach Options

MassDOT conducted the assessments of the highway interchange approach options in two detailed evaluations. The first detailed evaluation is documented in **Attachment 1, Cape Cod Bridges Program Alternatives Analysis Report**.

Using the alternatives identified in its 2017 Cape Cod Canal Area Transportation Study as its starting point, MassDOT conceptually identified and screened a total of 97 highway interchange approach concepts (the Universe of Concepts) according to feasibility and reasonability. From the screening of the Universe of Concepts, MassDOT identified 22 active concepts, where the concept was deemed to be a viable option to be further refined, for the highway interchange approaches at the four quadrants of the canal crossings: Bourne North, Bourne South, Sagamore North, and Sagamore South.

Incorporating the USACE's MRER/EA Preferred Alternative of In-Kind Bridge Replacement, and its recommendation for a Fully Offline Inboard location for the mainline alignment, MassDOT assessed the 22 highway interchange approach options relative to the Program's highway design evaluation criteria developed in collaboration with FHWA. Based on 2050 No Build Alternative condition traffic volumes, MassDOT assessed future traffic operations using several traffic analysis and modeling programs and conducted engineering assessments consistent with AASHTO's Highway Safety Manual. Highway interchange approach options were rated based on their performance relative to meeting the Program's highway design evaluation criteria; the ratings were then compared to identify options that MassDOT would recommend for a detailed, secondary level of assessment. Based on its initial assessment, MassDOT recommended a secondary evaluation of 10 highway interchange approach options for the four quadrants of the canal crossings.

## 4 Summary of Highway Interchange Approach Detailed Assessment Report

### 4.1 Overview

**Attachment 2, Cape Cod Bridges Program - Highway Interchange Approaches Detailed Assessment Report**, provides the secondary evaluation of the ten highway interchange options that passed the initial evaluations (described in [Section 3.8](#)). MassDOT prepared this report to document the detailed assessment of the highway interchange approach options that were considered for the Bourne and Sagamore replacement bridges, and then either not carried forward or advanced for incorporation into the Build Alternative Retained for Detailed Study in the Program's NEPA environmental review. The following summarizes the two-step approach MassDOT used to conduct detailed assessments of the highway interchange approach options.

### 4.2 Regional Traffic Operations Assessment

In Step 1, MassDOT focused on network (regional)-wide transportation performance measures. Based on the pairing of one option each for the Bourne North, Bourne South, Sagamore North, and Sagamore South quadrants, MassDOT identified 36 possible permutations of options. MassDOT then narrowed the number of permutations to eliminate pairings that performed similarly and conducted multiple analyses of the remaining permutations. The purpose of these multiple analyses was:

1. To determine if there were options in one area of the network that could adversely affect the performance of options in other areas of the network.
2. To identify options with fatal flaws that could adversely affect regional traffic operations.

MassDOT determined that options that would adversely affect overall network performance would be considered fatally flawed and would be eliminated from further analysis. MassDOT determined that highway interchange options that scored well regarding regional traffic operations would advance to further evaluation (Step 2) based on the Program Purpose and Need Statement evaluation criteria and the Program's goals and objectives.

### 4.3 Program Needs and Goals Performance Assessment

In the second step, MassDOT advanced highway interchange options that passed Step 1 to a Step 2 evaluation. MassDOT identified transportation performance measures and contextual performance measures and then evaluated the options relative to the Program needs and the Program goals and objectives. Transportation performance measures addressed the four overall Program needs identified in the Purpose and Need Statement:

- **Operations**, focusing on poor vehicular traffic operations, including high traffic volumes and congestion resulting in poor levels of service.

- **Geometrics and Safety**, focusing on the substandard design elements of the Cape Cod Canal highway bridges, the immediate mainline approaches, and their adjacent interchanges and intersections, including abrupt and steep connections to surface roads and nonconforming traffic safety features.
- **Multimodal Accommodations**, focusing on the lack of accessible bicycle and pedestrian accommodations and connections between existing facilities, including gaps and unsafe conditions across the canal and between local area roadways.
- **Structural and Maintenance**, focusing on the deteriorating structural condition and escalating maintenance demands of the existing Cape Cod Canal highway bridges, including the needed major rehabilitation programs identified by the USACE in the MRER/EA.

Contextual performance measures address the Program goals and objectives:

- Maintain and improve the socioeconomic fabric of the surrounding community (Socioeconomics).
- Preserve and protect natural resources (Natural Resources).
- Enhance the resiliency and sustainability of the built environment (Resiliency and Sustainability).
- Maximize constructability (Constructability).
- Facilitate emergency response (Emergency Response).
- Maximize cost effectiveness (Cost Effectiveness).

## 4.4 Summary of Evaluation

MassDOT developed a scoring system for evaluating the highway interchange approach options based on their quantitative and qualitative performance. Relative to meeting Program needs, an option was rated according to the benefits it would provide compared to other options or the No Build Alternative condition; benefit ratings were determined to be *substantial*, *marginal/some*, or *insufficient/negligible*. Regarding meeting Program goals and objectives, an option was rated in one of two ways: 1) based on the effects that would incur compared to the other options, ranging from *more or most effects*, to *some effects*, to *no, less, or least effects*; or 2) based on the opportunities it would provide in meeting Program objectives compared to the other options, ranging from *more or most opportunity*, to *some opportunity*, to *less or least opportunity*.

Based on the results of the two-step evaluation process, MassDOT identified the highest-ranking interchange approach options, two per crossing, as the recommended interchange pairings to be incorporated into the Build Alternative to be Retained for Detailed Study in the Draft Environmental Impact Statement (DEIS).

The detailed evaluation criteria performance measures scoring matrices for the Bourne highway interchange options and the Sagamore highway interchange options, including quantitative comparisons of environmental effects, are provided in **Table 3-1** and **Table 3-2**, appended to **Attachment 2**.

## 5 Attachments

- Attachment 1, Cape Cod Bridges Program Alternatives Analysis Report (February 20, 2024; updated May 2025)
- Attachment 2, Cape Cod Bridges Program - Highway Interchange Approaches Detailed Assessment Report (May 2025)